UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

OFFICE OF
PREVENTION,
PESTICIDES AND
TOXIC SUBSTANCES

**Memorandum**

**DATE:**

**SUBJECT:** Biological and Economic Analysis of Diazinon on Spinach: Impacts of Cancellation

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**PEER REVIEW DATE:**

**SUMMARY**

Diazinon is used on spinach to control several widely distributed foliage-feeding insects, including leafminers, aphids, and flea beetles, as well as soil inhabiting pests, such as cutworms, wireworms, white grubs, springtails, garden symphylans, seed corn maggots, and fire ants. Although efficacious alternative chemicals are available for use against foliage feeding pests, no viable alternatives exist to manage soil pests. BEAD

believes that the impact of a diazinon cancellation could impose yield losses ranging from 40% - 50% in certain areas where soil insects are a primary concern. Economic impacts associated with a diazinon cancellation could amount to a 12% loss of industry revenues for the processed spinach market (Texas) and 24% loss on industry revenues for fresh spinach (California).

## LIMITATIONS AND SCOPE OF ANALYSIS

The scope of this analysis includes an examination of potential regional-level impacts associated with elimination (through a phase-out) of the use of diazinon in spinach. This mitigation scenario reflects the high health risks to mixers, loaders, and applicators as identified by the Health Effects Division of the Office of Pesticide Programs. This analysis does not attempt to address impacts associated with mitigation efforts targeted at workers reentering fields treated with diazinon, or potential mitigation for various environmental risks (i.e., risk mitigation for risks to terrestrial plants and organisms or water contamination).

There are limitations to this assessment. The impacts estimated by this analysis only represent potential short-term – 1 to 2 years – impacts on the spinach production system and per-acre returns. National impacts are calculated by simply scaling up the estimated per-acre impacts. We ignore potential changes in price that may result from production changes and estimated grower impacts assume there will be no shift from spinach to other crops. Per-acre impacts are only broadly representative of impacts to grower income since the area infested by pests or treated with diazinon may be less than a grower's entire acreage.

Assumptions about yield and quality losses associated with the various scenarios are based on the best professional judgement of BEAD analysts when estimates were not available from other sources. Assumptions are based on a review of available USDA crop profiles, state crop production guides, discussions with university extension and research entomologists knowledgeable in spinach production, and other sources listed. Spinach production is a complex system that can be influenced by a variety of parameters (e. g., weather). BEAD's ability to quantitatively capture the wide array of events that could unfold given each hypothetical scenario listed above is very limited.

## CROP PRODUCTION

Spinach (*Spinacia oleracea* L.) is in the family Chenopodiaceae and is grown for both processing and the fresh market (Crop Profile for AZ, 2001). Spinach is a cool-season crop and is often planted in the spring or fall, but in some areas may be grown throughout the year. Once planted, fresh market spinach is typically grown for 30 to 55 days before harvest, and processing spinach is grown for 55 to 130 days before harvest occurs. Fresh market spinach is usually hand harvested but some is harvested mechanically. Processed spinach is mechanically harvested (Crop Profile for CA, 1999).

### Fresh Market Spinach

California is the major producer of fresh spinach in the United States, followed by Arizona, Texas and New Jersey. These four states combined supply about 93% of the fresh spinach market. Seven other states grow spinach for the fresh market, but in much lesser quantities (Table 1). Almost half of the California spinach production occurs in Monterey County, but the Salinas Valley and San Joaquin Valley also harvest spinach in significant quantities (Crop Profile for CA, 1999). In Arizona, production occurs primarily in Maricopa county.

**Table 1. Average Area, Production, and Value of Fresh Market Spinach: 1998-2000.**

| State | Acres Harvested (000) | Production (1,000 cwt.) | % of Total Production | Value per Unit ($/cwt.) | Total Value of Production (1,000 Dollars) | % of Total Value |
|---|---|---|---|---|---|---|
| Arizona | 3 | 782 | 19% | $30.90 | $24,164 | 18% |
| California | 16 | 2,700 | 65% | $33.27 | $84,692 | 63% |
| Colorado | 2 | 112 | 3% | $32.80 | $3,732 | 3% |
| Maryland | 1 | 77 | 3% | $35.33 | $2,652 | 2% |
| New Jersey | 2 | 167 | 4% | $35.00 | $5,812 | 4% |
| New York | 1 | 54 | 1% | $59.33 | $3,202 | 2% |
| Texas | 2 | 197 | 5% | $41.00 | $7,703 | 6% |
| Other states (DE, VA) | 1 | 54 | 1% | $33.00 | $1,782 | 2% |
| **Total** | **28** | **4,143** | **100%** | **$37.59‡** | **$133,739** | **100%** |

Source: USDA Agricultural Statistics 2001
‡Average value per unit ($/cwt.)

Processed Market Spinach

Spinach grown for the processed market is most commonly associated with Texas, where almost one third of national production occurs. Approximately 11 other states reported processed spinach production since 1998, however, statistical data collection for some states has been discontinued (Table 2).

**Table 2. Average Area, Production, and Value of Spinach for Processing: 1998-2000.**

| State | Acres Harvested (000) | Production (1,000 tons) | % of Total Production | Value per Unit ($/ton) | Total Value of Production (1,000 Dollars) | % of Total Value |
|---|---|---|---|---|---|---|
| Texas | 5 | 45 | 34% | $92.40 | $4,165 | 27% |
| Other* | 10 | 86 | 66% | $131.00 | $11,271 | 73% |
| **Total** | **15** | **131** | **100%** | **$111.70‡** | **$15,436** | **100%** |

Source: USDA Agricultural Statistics 2001
*1998 - AR, CA, NY, OK, PA, TN and WI. 1999 - AR, CA, NY, OH, PA and TN. 2000 - CA, GA, NJ, NY, OH and TN.

‡Average value per unit ($/ton)

## DIAZINON USAGE ON SPINACH

Over the period 1990-1999, average annual use of diazinon was approximately 6,000 lbs. of active ingredient applied on about 4,000 acres (BEAD, 2000). This is a ten year weighted average calculated using multiple data sources. USDA statistics from 1992-2000 report historical use of diazinon showing a slightly upward trend for both percent of crop treated and total pounds applied. In the most recent years, however, usage spiked dramatically, more than doubling the 1998 percent crop treated estimate and almost as much for total pounds applied (Table 3). Growers appear to prefer diazinon because of the favorable market price and ability to provide sufficient control for certain foliar and soil insects. Although alternatives exist for foliar insect

**Table 3. Historical usage pattern for diazinon on fresh spinach.**

| Year | Acres treated (%) | Applications (number) | Application rate (lbs per acre) | Total applied (lbs) |
|---|---|---|---|---|
| 2000 | 54% | 1.00 | 1.42 | 16,900 |
| 1998 | 26% | 1.40 | 1.90 | 9,700 |
| 1996 | 26% | 2.00 | 1.85 | 5,900 |
| 1994 | 24% | 1.60 | 1.63 | 4,200 |
| 1992 | 19% | 1.10 | 1.91 | 2,800 |
| **Average** | **30%** | **1.42** | **1.74** | **7,900** |

Source: USDA Agricultural Chemical Usage: Vegetable Summary 1992,1994, 1996, 1998 , 2000

The primary state using diazinon on fresh spinach is California, treating approximately 57% of harvested acres (USDA). Both New Jersey and Texas reported use, however, the data were not published (Table 4).

**Table 4. Diazinon usage on fresh spinach, 2000**

| Region | Percent Crop Treated | Base Area Treated | lbs. a.i. Applied | no. of Applications | lbs. a.i. per Acre per Year |
|---|---|---|---|---|---|
| California | 57% | 17,000 | 14,700 | 1 | 1.51 |

Source: USDA Agricultural Chemical Usage: 2000 Vegetable Summary.

Historical usage information for processed spinach is limited, however, within the last ten years approximately 2,000 pounds of diazinon were applied annually on about 2,000 acres (BEAD, 2000). Most reported usage occurred in Texas (Table 5).

**Table 5. Historical usage pattern for diazinon on spinach for processing**

| Year | Acres treated (%) | Applications (number) | Application rate (lbs per acre) | Total applied (lbs) |
|---|---|---|---|---|
| 1996* | 24% | 1.1 | 1.18 | 800 |
| 1992‡ | 23% | 1.1 | 0.62 | 1,800 |

*Source: USDA Agricultural Chemical Usage - Vegetables 1996
‡Includes four major states: CA, NJ, NY and TX

### Target Insect Pests and Control

Diazinon is used to control several widely distributed insects that attack spinach in most producing states. Several species of leafminers, aphids (green peach, cotton/melon, bean), flea beetles, and cutworms feed on spinach foliage. Leafminers live and feed in winding mines in between the leaf surfaces, reducing crop quality. Aphids feed on the plant phloem, stunting growth and secreting honeydew. Flea beetles chew round holes on the leaves, while cutworms chew large portions of foliage, often killing seedlings and young plants. Wireworms, white grubs, and the seed corn maggot attack the root, often killing young plants. Minor diazinon target pests include crickets, true bugs, and other homopterans.

Several insects controlled by diazinon on spinach have a more limited distribution. In Texas, fire ants may attack spinach seeds and seedlings, requiring control, although later in the season these ants prey on leaf-feeding insects, thus shifting to a role as biocontrol agents. Fire ants and soil insect pests, particularly white grubs, are an annual problem. One treatment of diazinon will usually control fire ants for approximately 6 weeks, at which point they begin attacking other spinach pests. In the absence of diazinon, fire ants would likely be treated with permethrin, although because of its shorter (one week) residual activity, several applications would be necessary (N. Troxclaire, Personal Communiation).

In California, especially in the cooler and wetter coastal valleys, wireworms, springtails, the garden symphylan, and flea beetles are major pests of leafy vegetables, including spinach. These soil pests kill seedlings by feeding on roots and boring into stems. Soil pest damage is more severe for spring plantings, in fields with high organic content. As a preventive measure, diazinon is used as a preplant application, since severely infested fields would need to be replanted if these pests are not controlled (F. Sances, Personal Communication).

In Delaware, the seed corn maggot may affect 20% of the acreage. In West Virginia, leafminers may cause up to 25-50% leaf damage in some fields, rendering the crop unprofitable (West Virginia University Extension Service, Pesticide Certification Information #14). In the East Coast, diazinon is used to control primarily the seed corn maggot, white grubs, and wireworms. A few maggots per seed or seedling can significantly reduce stands. However this pest is sporadic and likely to cause problems only in cool, wet springs. Moreover, its distribution is limited by the sandy soils and lack of organic matter found in this growing region. Due to the nature of soil insect pests damage, severely infested fields would need to be replanted.

## ALTERNATIVE CONTROL METHODS

Several alternative insecticides are available for control of aphids, including malathion (organophosphates),

imidacloprid (neonicotinoid), and pymetrozine (azomethrine compound). Pyrethrins, azadirachtin, and insecticidal soaps are also used by some farmers. Similarly, several alternatives exist for leafminer control, including spinosad (actinomycete, fermentation product), abamectin (avermectin), permethrin (pyrethroid), and cyromazine (insect growth regulator). Azadirachtin and pyrethrins may also be used occasionally. Flea beetles may be controlled with methomyl (carbamate) and several pyrethroids, such as permethrin, cypermethrin, and lambda-cyhalothrin. Fire ants may be controlled with pyrethroids. A granular carbaryl formulation is available for cutworm control.

There are no available alternative insecticides for control of soil insects, including the seed corn maggot.

## IMPACTS OF MITIGATION OF CHEMICAL

### Biological Impacts

In Texas' winter garden area, soil insects (fire ants, cutworms, white grubs, wireworms) affect 100% of the spinach acreage (USDA Crop Profile for Spinach in Texas, Ray Prewett 2001). Since alternatives are not available for soil insect control in spinach, damage in Texas may cause up to 40 - 50% yield loss. In some cases, affected fields can be replanted at a cost of about $200 per acre. (N. Troxclaire, personal communication). Losing diazinon would likely result in less than 5% yield loss to soil insect problems in Virginia (T. Kuhar, personal communication). In Delaware, a 30 to 40% stand loss is possible in some fields if soil insects are uncontrolled, requiring that the affected fields be replanted at an estimated cost of $180-200 per acre (Whalen, 2002). Similarly, the loss of diazinon would adversely affect California spinach, where the cost of replanting fields damaged by soil pests would likely exceed the cost estimated for Delaware (M. Mason, personal communication).

Because alternatives are available for aphid, leafminer, flea beetle, and fire ant control in spinach, cancellation of diazinon for these uses should not significantly affect the spinach industry. However, since alternative insecticides are not available to manage soil pests, the loss of this diazinon use is expected to have a major impact on the spinach industry.

### Economic Impacts

Per-acre Impacts: Fresh Market Spinach

A crop budget approach was used to determine the economic impact to fresh market spinach producers facing a hypothetical cancellation of diazinon. The focus of this analysis will be California, the leading state in fresh market spinach production. Sample production costs were obtained from the California Cooperative Extension in order to evaluate potential impacts to a typical fresh market spinach grower. These budgets are reflective of the likely incurred costs, but are not based on cost of production surveys.

Average yield and price data were utilized to determine gross returns per acre. Yields in California averaged 165 cwt. per acre from 1998-2000 at an average price of $33.27 per cwt. Gross revenues from 1998-2000 averaged approximately $5,489.55/acre. Table 6 presents gross returns, production costs and net cash returns for fresh market spinach production in Ventura County, California. These figures assume an application of about 1.6 pounds of diazinon per acre annually (BEAD 2000) to control soil and foliar insect pests and the subsequent effects of a hypothetical cancellation. Production impacts associated with diazinon

cancellation may lead to yield losses up to 40%. It must be noted that alternatives exist for foliar insects, therefore yield loss impacts are a factor of soil insect infestation only. EPA data shows that average production costs associated with applying diazinon are about $14.00/acre. Assuming application equipment remains the same and no other cultural changes lead to an increase in production costs, the expected impact would be a decrease of 0.4% on operating costs when eliminating diazinon from the expense budget. The combined impact resulting from a 40% yield reduction and slight input cost savings from not using diazinon will be a negative 116% reduction in revenues per acre for California spinach growers. The economic burden to growers may amount to losses of $2,182/acre. This analysis only reflects applications of diazinon to control soil insects. Diazinon provides some control for non-soil insects, however, alternatives exist and growers may likely opt for other methods of control. It should also be noted that this analysis attempts to evaluate the "worst case scenario" and may likely indicate an upper bound on grower impacts.

**Table 6. Gross returns, production costs and net returns to spinach production, Ventura County, California**

| | Base Scenario: diazinon | Alternative: none => 40% loss | % Change |
|---|---|---|---|
| production (cwt./acre) | 165 | 99 | 40% |
| price ($/cwt.) | $33.27 | $33.27 | |
| gross revenue ($/acre) | $5,489.55 | $3,293.73 | 40% |
| insecticide costs ($/acre) | | | |
| diazinon | $14.00 | | |
| other: | $29.00 | $29.00 | |
| other pre-harvest costs ($/acre) | $444 | $444.00 | |
| harvest costs ($/acre) | $3,129.00 | $3,129.00 | |
| total operating costs ($/acre) | $3,616.00 | $3,602.00 | 0.4% |
| NET CASH RETURNS ($/acre) | $1,873.55 | ($308.27) | 116% |

Industry Impacts: Fresh Market Spinach

Diazinon is applied on 57% (USDA 2001) of the bearing fresh market spinach acreage in California, or about 9,310 acres. Yield losses associated with diazinon cancellation could be up to 40% from soil insect infestation. Cost per acre impacts resulting from estimated yield losses could amount to $2,182. Given the range of the per acre economic burden facing growers (see above), annual industry losses can be calculated by multiplying the net economic loss facing growers by the number of acres treated with diazinon. This gives

an estimate of industry loss slightly more than $20 million annually. Average gross revenues from fresh market spinach production in the state of California exceed $84 million (Table 1). Comparing industry losses with gross revenues, the economic burden associated with a regulatory decision may lead to a loss of 24% of the gross value of the California fresh spinach industry revenues.

Per-acre Impacts: Processed Market Spinach

A crop budget approach was used to determine the economic impact to processed spinach producers facing a hypothetical cancellation of diazinon. The focus of this analysis will be Texas, the state with the most prevalent historical use pattern applying diazinon to processed market spinach. Sample production costs were obtained from the Texas Cooperative Extension in order to evaluate potential impacts to a typical processed market spinach grower. These budgets are reflective of the likely incurred costs, but are not based on cost of production surveys.

Average yield and price data were utilized to determine gross returns per acre. Yields in Texas averaged nine tons per acre from 1998-2000 at an average price of $92.40 per ton. Gross revenues from 1998-2000 averaged approximately $831.60/acre. Table 7 presents gross returns, production costs and net cash returns for processed market spinach production in southwest Texas. These figures assume an application of about 1.2 pounds of diazinon per acre annually (BEAD 2000) to control foliar and soil insect pests and the subsequent effects of a hypothetical cancellation. Production impacts associated with diazinon cancellation may lead to yield losses up to 50%. It must be noted that alternatives exist for foliar insects, therefore yield loss impacts are a factor of soil insect infestation only. EPA data show that average production costs associated with applying diazinon are about $5.00/acre. Assuming application equipment remains the same and no other cultural changes lead to an increase in production costs, the expected impact would be a decrease of 0.9% on operating costs when eliminating diazinon from the pest control regime. The combined impact resulting from a 50% yield reduction and slight input cost savings will be a negative 135% reduction in revenues per acre for Texas spinach growers. The economic burden to growers may amount to losses of $410.80/acre. This analysis only reflects applications of diazinon to control soil insects. Diazinon provides some control for non-soil insects, however, alternatives exist and growers may likely opt for other methods of control. It should be noted that this analysis attempts to evaluate the "worst case scenario" and may likely indicate an upper bound on grower impacts.

**Table 7. Gross returns, production costs and net returns to spinach production, Southwest Texas.**

| | Base Scenario: diazinon | Alternative: none => 50% loss | % Change |
|---|---|---|---|
| production (tons/acre) | 9 | 4.5 | 50% |
| price ($/ton) | $92.40 | $92.40 | |
| gross revenue ($/acre) | $831.60 | $415.80 | 50% |
| insecticide costs ($/acre) | | | |
| diazinon | $5.00 | | |
| other: | $45.00 | $45.00 | |

| | | | |
|---|---|---|---|
| other pre-harvest costs ($/acre) | $324.82 | $324.82 | |
| harvest costs ($/acre) | $152.37 | $152.37 | |
| total operating costs ($/acre) | $527.19 | $522.19 | 0.9% |
| NET CASH RETURNS ($/acre) | $304.41 | ($106.39) | 135% |

Industry Impacts: Processed Market Spinach

Diazinon is applied on 24% (BEAD 2000) of the bearing processed market spinach acreage in Texas, or about 1,200 acres. Yield losses associated with diazinon cancellation will be about 50% from soil insect infestation. Given the range of the per acre economic burden facing growers (see above), annual industry losses can be calculated by multiplying the net economic loss facing growers by the number of acres treated with diazinon. This gives an estimate of industry loss at about $492,960 annually. Average gross revenues from processed market spinach production in the state of Texas exceed 4 million dollars (Table 2). Comparing industry losses with gross revenues, the economic burden associated with a regulatory decision may lead to a loss of 12% of the gross value of the Texas processed spinach industry revenues.

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